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(54) A DUAL FUEL BURNER ASSEMBLY AND METHOD OF OPERATING A DUAL FUEL BURNER ASSEMBLY

DOPPELBRENNSTOFF-BRENNERANORDNUNG UND VERFAHREN ZUM BETRIEB EINER
DOPPELBRENNSTOFF-BRENNERANORDNUNG

ENSEMBLE BRÛLEUR À DOUBLE CARBURANT ET PROCÉDÉ DE FONCTIONNEMENT D'UN
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Description**Technical field**

- 5 **[0001]** The present invention relates to a dual fuel burner assembly according to the preamble of claim 1. The invention relates also method of operating to a dual fuel burner assembly.

Background art

- 10 **[0002]** Combustion is a major source of pollutants. Oxides of nitrogen, or NO_x, (NO or nitric oxide, NO₂ or nitrogen dioxide, and N₂O or nitrous oxide) contribute to acid rain, smog, global warming, and ozone depletion. As NO_x emissions from combustion sources primarily consist of nitric oxide, an understanding of how NO is generated is important. There are three principal mechanisms which produce NO during combustion: the fuel NO mechanism; prompt NO mechanisms; and the "thermal NO".
- 15 **[0003]** The fuel to be combusted can be premixed to the combustion air or it can be introduced into the air immediately prior to combustion. Swirling flows have been used to stabilize combustion in a variety of burners, both premixed and non-premixed. Swirl in these burners is generally created either by generating tangential flow motion in a cylindrical chamber, as in cyclone combustion chambers, or swirling a co-axial air flow. In both cases, the function of the swirl is to create a toroidal recirculation zone.
- 20 **[0004]** US patent 5879148 discloses a mechanical swirler for generating diverging flow in lean premixed burners. The swirler includes a central passage with an entrance for accepting a feed gas, a flow balancing insert that introduces additional pressure drop beyond that occurring in the central passage in the absence of the flow balancing insert, and an exit aligned to direct the feed gas into a combustor. The swirler also has an annular passage about the central passage and including one or more vanes oriented to impart angular momentum to feed gas exiting the annular passage. The diverging flow generated by the swirler stabilizes lean combustion thus allowing for lower production of pollutants, particularly oxides of nitrogen. This kind of a burner needs to have the fuel and oxidizer mixed prior to burner entry (i.e. entry of vane swirler). The mixing zone design is critical in such respect as it determines the flame profile and turn-down ratio i.e. the ratio of the maximum capacity to minimum capacity.
- 25 **[0005]** US5240410 discloses a structure of a burner which can be fuelled with gas fuel or oil fuel. The main features includes: a specially designed swirl generator; an annular hollow gas gun; an oil gun received in the gas gun where the gas jets of the gas gun and the oil jets of the oil gun have a predetermined angle with respect to the centerline. Under designed operating conditions, a swirling air flow can be generated with a low pressure drop and low turbulences, which is beneficial to flame stability, reducing flame temperature, and delaying the mixing of air and fuel, thus inhibiting the formation of NO_x. Staging air and flue gas recirculation are available for further reduction of nitrogen oxides. The gas gun and the oil gun are detachable and their positions are adjustable, whereby an operating person can adjust the fuel supply.
- 30 **[0006]** An object of the invention is to provide a dual fuel burner in which the NO emissions can be maintained considerable low during operating the burner either by gaseous or liquid fuel.
- 35

40 **Disclosure of the Invention**

- [0007]** Objects of the invention can be met substantially as is disclosed in the independent claims and in the other claims describing more details of different embodiments of the invention.
- 45 **[0008]** A dual fuel burner assembly comprises a duct part arranged into the burner, a combustion air inlet opening in a first end of the duct part, an outlet at the second end of the duct part and a second fuel inlet and a first fuel inlet. And further the duct part is provided with a swirl section between the air inlet and the outlet of the burner assembly, and the swirl section comprises an annular outer flow channel and a central flow channel radially enclosed by the outer flow channel, and the annular flow channel is provided with vanes arranged to provide a tangential component to a gas flowing through the annular flow channel when in use. The central flow channel is provided with a damper configured to adjust flow resistance of the central flow channel, and that the first fuel inlet is arranged coaxially with annular flow channel of the swirl section in the vicinity of the outlet of the burner.
- 50 **[0009]** This way the burner can be set to operation as a dual fuel burner for combusting gaseous fuel and liquid fuel alternatively.
- [0010]** According to an embodiment of the invention the damper in the central flow channel comprises a first screen member and a second screen member arranged consecutively into the central flow channel, which screen members are provided with openings which can be aligned or at least partially misaligned with each other depending on the mutual rotational positions of the first screen member and the second screen member.
- 55 **[0011]** According to an embodiment of the invention the damper in the central flow channel comprises a first screen

member provided with openings and a second screen member provided with openings, arranged consecutively into the central flow channel, and that the screen members are arranged movable in respect to each other such that their mutual axial distance is arranged adjustable.

[0012] According to an embodiment of the invention the damper in the central flow channel is a multi-plate butterfly damper.

[0013] According to an embodiment of the invention the damper in the central flow channel is a vane damper provided with multiple radial vanes.

[0014] According to an embodiment of the invention the first fuel inlet comprises a feed pipe arranged coaxially with annular flow channel of the swirl section which feed pipe extends longitudinally through the duct part, into which feed pipe the first fuel inlet is arranged.

[0015] According to an embodiment of the invention first fuel inlet comprises a central feed pipe arranged rotatably in respect to its longitudinal axis and the first screen member is fixed to a body of the swirl section and the second screen member is fixed to the feed pipe such the second screen member is rotatably by the central feed pipe in respect to the first screen member.

[0016] According to an embodiment of the invention the burner comprises a mixing part arranged between the air inlet and the swirl section arranged for mixing the second fuel and combustion air prior to introduction into the swirl section.

[0017] According to an embodiment of the invention the burner assembly is dimensioned so that a swirl number (S), which is defined by the function

$$S = \frac{2}{3} \tan \alpha \frac{1 - R^3}{1 - R^2 + \left[m^2 \left(\frac{1}{R^2} - 1 \right)^2 \right] R^2}$$

where

α = vane angle at the trailing end in respect to the longitudinal axis (°)

$$m = m_c / m_s$$

m_c = mass flow rate through the central flow channel

m_s = mass flow rate through the annular flow channel

$$R = R_b / R_B$$

R_B = Burner duct part radius

R_b = Central flow channel radius

is between 0,4 and 0,55, when the vane angle is between 30° - 42° and the ratio R is 0,5 - 0,7.

[0018] Method of operating a dual fuel burner assembly according to the invention combusting a second fuel and a first fuel alternatively comprises combusting the second fuel by maintaining the damper in the central flow channel in a first open position, introducing the second fuel into the combustion air upstream the swirl section of the duct part while refrain from the introduction of the first fuel, and leading first portion of the fuel-air mixture through the central flow channel and a second portion of the fuel-air mixture through the annular flow channel and thus subjecting the second portion into tangential swirl prior to combustion of the second fuel, and by combusting the first fuel by maintaining the damper in the central flow channel in a second open position - providing greater flow resistance than the first open position, or by closing the damper in the central flow channel while refrain from the introduction of the second fuel, and leading the combustion air through the annular flow channel and subjecting the combustion air into tangential swirl and introducing the first fuel coaxially with the annular flow channel.

[0019] According to an embodiment of the invention during the combustion of the second fuel adjusting the damper is adjusted so that a swirl number S, which is defined by the function

$$S = \frac{2}{3} \tan \alpha \frac{1 - R^3}{1 - R^2 + \left[m^2 \left(\frac{1}{R^2} - 1 \right)^2 \right] R^2}$$

where

α = vane angle at the trailing end in respect to the longitudinal axis (°)

$$m = m_c / m_s$$

m_c = mass flow rate through the central flow channel

m_s = mass flow rate through the annular flow channel

$$R = R_b / R_B$$

R_B = Burner duct part radius

R_b = Central flow channel radius

is between 0,4 and 0,55, when the vane angle is between 30° - 42° and the ratio R is 0,5 - 0,7.

[0020] The exemplary embodiments of the invention presented in this patent application are not to be interpreted to pose limitations to the applicability of the appended claims. The verb "to comprise" is used in this patent application as an open limitation that does not exclude the existence of also unrecited features. The features recited in depending claims are mutually freely combinable unless otherwise explicitly stated. The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims.

[0021] Invention provides several advantages. By means of the dual fuel burner according to the invention it is possible to combust either gaseous fuel or liquid fuel alternatively which simultaneously provide adequately low CO and NOx emissions with both fuels. The burner assembly is simple and technically straight forward and it provides reliable operation and long service life.

Brief Description of Drawings

[0022] In the following, the invention will be described with reference to the accompanying exemplary, schematic drawings, in which

Figure 1 illustrates a dual fuel burner assembly according to an embodiment of the invention,

Figure 2 illustrates a dual fuel burner assembly according to another embodiment of the invention, and

Figure 3a illustrates an embodiment of the swirl section according to another embodiment of the invention,

Figure 3b illustrates another embodiment of the swirl section according to another embodiment of the invention,

Figure 4 illustrates a dual fuel burner assembly according to another embodiment of the invention,

Figure 5a illustrates an embodiment of the swirl section according to another embodiment of the invention, and

Figure 5b illustrates another embodiment of the swirl section according to another embodiment of the invention.

Detailed Description of Drawings

[0023] Figure 1 depicts schematically a dual fuel burner assembly 10 according to an embodiment of the invention which is configured to combust alternatively liquid fuel, such as a light fuel oil, and gaseous fuel, such as LNG, LPG,

etc.. Figure 2 depicts schematically a dual fuel burner assembly 10 according to another embodiment of the invention which is configured to combust alternatively liquid fuel, such as a light fuel oil, and gaseous fuel, such as LNG, LPG, etc. In the following the dual fuel burner assembly 10 is referred to as a burner 10 for sake of simplicity.

[0024] With a reference to the figures 1 and 2 the burner 10 comprises a duct part 12 via which the air needed for combustion of fuel is introduced into a combustion section 16 functionally attached to the burner 10. The combustion section 16 is shown here only indicatively since it may be an integral part of the burner or it may structurally belong to a combustor, such as a refractory lining, where the burner is attached to. The combustion section 16 is also an outlet of the duct part 12. The duct part 12 is generally of circular cross section having a longitudinal center axis 14. In the figures 1 and 2 the duct part is substantially of constant diameter, but that is not essential to the operation of the burner. The duct part 12 comprises an inlet section or a first end of the duct part 12.1 and a head section 12.2 via which air or a mixture of the air and gaseous fuel is fed to and through the burner 10 depending on the mode of operation. The inlet section 12.1 is primarily an air inlet 15. The burner 10 is a dual fuel burner and therefore it comprises means for introducing a first and a second fuel into the burner 10.

[0025] In the embodiment of the figure 1 the means for introducing the first fuel comprises a first fuel inlet 19 for liquid fuel and the means for introducing the second fuel comprises the inlet 15 of the inlet section 12.1, which is a common inlet for the combustion air and the fuel i.e. the second fuel is gaseous fuel and it has been admitted into the air prior to introduction of the mixture to the burner 10.

[0026] In the embodiment shown in the figure 2 the burner 10 is provided also with a second fuel inlet 17 for introducing the second fuel, which is gaseous fuel. According to the embodiment, which is shown in the figure 2, the first inlet 15 serves for introduction of the air only, and the burner is provided with a separate gas admission valve, i.e. a second fuel inlet 17 in connection with the inlet section 12.1 for introducing the second fuel into the combustion air.

[0027] The duct part 12 comprises a transition and mixing part 18 by means of which the change of the angle between the inlet section 12.1 and the head section 12.2 is accomplished i.e. the change of direction of the sections and simultaneously the mixing of the gaseous fuel into the combustion air is finalized. The mixing of the second fuel and air may be realized by any feasible manner, other than shown here, or in addition to the mixing part 18 shown in the figures 1 and 2. The angle need not to be exactly a right angle, but the angle of more than 45 degrees would suffice. In the figures 1 and 2 the transition part 18 comprises a set of guide vanes 20 which facilitates smooth change of flow direction of the air. The guide vanes 20 has their leading edge in the direction of the first section 14.1 of the longitudinal center axis 14 and their trailing edge in the direction of the second section 14.2 of the longitudinal center axis 14. The set of guide vanes 20 forms a grid which covers the whole face area of the duct part. By using the guide vanes the inlet section 12.1 and the head section 12.2 can be arranged to meet even at a right angle with each other, as is shown in the figures 1 and 2.

[0028] The first fuel inlet 19 is arranged at an end of a feed pipe 22, which is arranged into the head section 12.2 of burner 10. More particularly, the feed pipe 22 is mainly comprised of an elongated tube 23 arranged coaxially with the longitudinal center axis 14.1 of the burner 10 and with the annular flow channel of the swirl section. The feed pipe 22 extends longitudinally through the head section 12.2 of the duct part 12 and further through a wall 12.1' of the inlet section 12.1. The duct part 12 comprises a lead through and a support sleeve 24 to facilitate rotatable support of the body part 23 to the wall 12.1'.

[0029] The burner 10 is provided with a swirl section 30 arranged to the duct part 12, more particularly to the head section 12.2 of the duct part. The swirl section 30 is arranged between the air inlet 15 and the outlet 16 of the burner 10. Also the mixing part 18 is arranged between the air inlet 15 and the swirl section 30 for mixing the second fuel and combustion air prior to introduction into the swirl section 30.

[0030] The swirl section 30 comprises an annular outer flow channel 32 and a central flow channel 34 which is enclosed by the annular flow channel 32. The outer flow channel 32 and the central flow channel 32 are coaxial with the body part 23 of the feed pipe 22. A cylindrical outer wall 12.2' of the head section 12.2 and a cylindrical intermediate wall 36, which is coaxial with the outer wall 12.2', define the annular outer flow channel 32 radially between the walls. The central flow channel 34 is formed inside the cylindrical intermediate wall 36. The annular flow channel is provided with vanes 38 which are configured to provide a tangential component, i.e. a swirl, to the gas flowing through the annular flow channel, when in use as a burner. The central flow channel 34 has a length in the direction of the center axis 14. The central flow channel 34 is provided with a flow damper 40 which is configured to adjust gas flow resistance of the central flow channel. The damper 40 is usually located at the inlet or outlet of the central flow channel 34, but it can be also located at any axial position of the channel 34 as long as it provides a desired damping effect.. The first fuel inlet 19 is arranged coaxially with the annular flow channel 38 of the swirl section 30 in the vicinity of the outlet 16 of the burner. The damper 40 is configured to control the flow of combustion air (or the mixture of the air and the second fuel) between the central flow channel 34 and the annular flow channel 32 depending on the prevailing mode of operation of the burner 10. In the figure 1 there is shown one vane 38 by a dotted line which indicates also the angle α which is the vane angle at the trailing end in respect to the longitudinal axis used in the equation of swirl number S to be introduced later. The longitudinal position of the damper may vary within the swirl section 30.

[0031] The damper 40 together with the means for introducing first and second fuel into the burner 15, 17, 19 and the

swirl section provide a contribution to operate the burner assembly alternatively in two different manners. The swirl section splits the reactants present in the combustion process i.e. the mixture of gaseous fuel and oxidizer (air) in two channels by means of which the unswirled flow is taken place in the central channel which prevents vortex breakdown i.e. minimizes formation of a recirculation zone in the combustion process and the vanes induce swirling motion in the annulus. The damper controls the unswirled and swirled flow division and the interaction of the flow split, i.e. unswirled and swirled, forms a divergent flow field upon burner 10.

[0032] According to an embodiment of the invention, in the first mode of operation the first fuel, which is liquid fuel, is combusted in the burner. The burner 10 is set for the operation by closing the damper 40 in the central flow channel 34. In this mode of operation it is refrained from the introduction of the second fuel 17 and the combustion air is led solely through the annular flow channel 32. This way the combustion air is brought into a strong tangential swirl. The first fuel is introduced coaxially with the annular flow channel into the swirl of combustion air and is combusted. Since practically all the combustion air is led through the annular flow channel 32 a strong swirl motion is generated. The strong swirl stabilizes the flame at the outlet 16 i.e. the combustion section, which is conical of its form. Due to the high swirling motion generated by the swirl vanes 38, the flow of the air and combustion gases at the combustion section form an internal recirculation zone, which may also be referred to as a toroidal vortex core, which internal recirculation zone provides turbulent mixing of oxidizer and air. This ensures a low CO content in the flue gas. When additionally a portion of the flue gases are recirculated internally or externally the NO_x formation can be reduced to required level, say below 10 ppm. Other optional way to reduce NO_x emissions are using water injection into the flame which reduces the peak temperatures and thus formation of so called thermal NO_x. Also selective catalytic reduction methods are usable for the purpose.

[0033] In the second mode of operation the burner 10 is operated by combusting the second fuel which is gaseous fuel. In the second mode of operation the damper 40 in the central flow channel is maintained open, which cause the combustion air to flow through both the central flow channel 34 and the annular flow channel 32. In the second mode of operation the second fuel, which is in gaseous form, is introduced into the combustion air upstream the swirl section 30 of the duct part 12 and premixed with the air prior to combustion. In this mode of operation it is refrained from the introduction of the first fuel. Now the damper 40 is at a position which results in that a first portion of the fuel-air mixture is led through the central flow channel and a second portion of the fuel-air mixture through the annular flow channel and only the second portion is subjected into tangential swirl prior to combustion of the second fuel. Therefore the swirl is only provided to the first portion and therefore only a moderate swirl rate is generated. When combusting gaseous fuel, such as methane, the second mode of operation proves very low (<10 ppm) CO and NO_x emissions practically without a need for any additional emission reduction means. The swirl section 30 itself has a great deal of influence on the operation of the burner 10. The swirl section 30 needs to serve both the first mode of operation and the second mode of operation. The damper 40, i.e. the position of the damper rules the gas flow rate flowing through the annular outer flow channel 32, which effects on the swirl rate generated into the flame. This way the vanes 38 can be designed to be usable for both of the operational modes.

[0034] The damper 40 in the central flow channel 34 of the swirl section is configured to open or close or control the flow resistance of the flow path through the central flow channel 34. As can be seen in the figures 1 and 2 the damper 40 comprises a first screen member 41 and a second screen member 42. The screen members 41, 42 are arranged consecutively in the direction of the center axis 14 into the central flow channel 34 substantially face to face to each other. The screen members 41, 42 are provided with openings 44, which can be aligned or misaligned depending on the mutual rotational positions of the first screen member and the second screen member. In the figures 1 and 2 the openings 43 through the plate are at equal positions, which is not however essential. The screen member 41, 42 are positioned in the figures 1 and 2 such that the openings 43 are aligned with each other and the damper 40 is therefore open.

[0035] The damper may be comprised of more than two screen members with suitable openings.

[0036] The central feed pipe 22 of the first fuel inlet 19 is arranged rotatably in respect to its longitudinal axis. Since the feed pipe 22 extends out from the head section 12.2 of the burner 10 it can be rotated by applying torque to the portion outside the burner. The feed pipe 22 may be provided with a mechanical actuator for rotating it suitably. The first screen member is releasably fixed to a body of the swirl section 30, more particularly to the intermediate wall 36 and the second screen member is releasably fixed to the feed pipe 22 such the second screen member 42 is rotatably by means of the central feed pipe 22. Thus if the feed pipe 22 is rotated the second screen member 42 rotates respectively.

[0037] In the second mode of operation which may be referred to also as a low swirl operation, a so-called swirl number, S, is the primary design parameter

[0038] The swirl number is defined by the following equation

$$S = \frac{2}{3} \tan \alpha \frac{1 - R^3}{1 - R^2 + \left[m^2 \left(\frac{1}{R^2} - 1 \right)^2 \right] R^2}$$

where

α = Vane angle at the trailing end in respect to the longitudinal axis (°)

$$m = m_c / m_s$$

m_c = mass flow rate through the central flow channel

m_s = mass flow rate through the annular flow channel

$$R = R_b / R_B$$

R_B = Burner duct part radius (mm)

R_b = Central flow channel radius (mm)

[0039] The burner assembly according to the invention is dimensioned so that the swirl number S is between 0,40 and 0,55. The vane angle is between 30° - 42° when low hydrogen or hydrocarbon fuel, such as methane is used. If the fuel is hydrogen rich, such as pure hydrogen, the vane angle is advantageously between 30° - 35°. This results in stable and reliable operation. It has also been found that the ratio R is advantageously 0,5 - 0,7.

[0040] Figure 3 discloses two different embodiments of the swirl section 30 and the damper 40 shown from the direction II as is depicted by the arrow in the figure 1. The first screen member is shown by a solid line and the second screen member 42 by a dotted line. The openings 43 in the screen members 41,42 in the figure 2a are non-circular indicating that the actual form of the opening may be selected to be of various forms. The damper 40 in the figure 2a is such that it can be totally closed i.e. the openings in the first one of the screen members can be rotated to be between openings in the second one of the screen members. The openings 43 in the screen members 41,42 in the figure 2b are circular. The damper 40 in the figure 2a is such that it cannot be totally closed i.e. the amount, size and or positioning of the openings in the first one of the screen members is such that there are, independently from the rotationally position of the first screen member, always openings which are at least partially overlapping with the openings in the second one of the screen members. Thus the damper in the 2b can only adjust the flow resistance of the damper but not close it totally.

[0041] Figure 4 shows an embodiment of the invention in which the damper 40 in the central flow channel 34 comprises a first screen member 41 provided with openings 43 and a second screen member 42 provided with openings 43. The screens may be for example substantially similar to those discussed above, but the control of the operation of the damper is different. The screen members are arranged consecutively into the central flow channel 34, and the flow resistance of the central flow channel 34 is controllable so that the screen members 41, 42 are arranged movable in respect to each other such that their mutual axial distance is arranged adjustable. The screen members 41, 42 are provided with openings 43 which are axially misaligned with each other. In this way when the screen members are against each other, which position is shown by dotted line in the figure 3, only minimal open face area is formed by the successive screen members. On the other hand when the second screen member 42 is moved away from the first screen member the openings 43 are spaced from each other and the gas may flow through the damper 40. Figure 5 shows various embodiments of the swirl section 30 according to the invention. Figure 5a illustrates an embodiment where the damper 40 in the central flow channel is a multi-plate butterfly damper in which more than one damper plates 40' are arranged rotatably in respect to its central axis 39'. The damper plates are supported by shaft which can be rotated with suitable actuators (not shown). Figure 5b illustrates another embodiment where the damper 40 in the central flow channel is a vane damper provided with multiple radial vanes 40" are arranged rotatably in respect to its radially extending axis 39'. The damper plates i.e. the radial vanes are supported by suitable shafts, which in turn can be rotated with suitable actuators, which are not shown here.

[0042] While the invention has been described herein by way of examples in connection with what are, at present, considered to be the most preferred embodiments, it is to be understood that the invention is not limited to the disclosed embodiments, but is intended to cover various combinations or modifications of its features, and several other applications included within the scope of the invention, as defined in the appended claims. The details mentioned in connection with any embodiment above may be used in connection with another embodiment when such combination is technically feasible.

Claims

1. A dual fuel burner assembly (10) comprising a duct part (12) for introducing combustion air, an inlet (15) of the duct part (12) at its first end, an outlet (16) of the duct part at its second end and means for introducing first and second fuel into the burner (15,17,19), wherein the duct part (12) is provided with a swirl section (30) between the inlet (15) and the outlet (16), and the swirl section (30) of the duct part (12) comprises an annular outer flow channel (32) provided with vanes (38) arranged to provide a tangential component to a gas flowing through the annular flow channel when in use, and the means for introducing fuel into the burner (15,17,19) comprises a first fuel inlet (19) which is arranged coaxially with annular flow channel (32) of the swirl section in the vicinity of the outlet (16) of the burner, **characterized in that** the swirl section of the duct part for introducing combustion air comprises a central flow channel (34) radially enclosed by the outer flow channel (32), and the central flow channel (34) of the duct part (12) is provided with a damper (40) configured to adjust flow resistance of the central flow channel (34).
2. A dual fuel burner assembly according to claim 1, **characterized in that** the damper (40) in the central flow channel (34) comprises a first screen member (41) and a second screen member (42) arranged consecutively into the central flow channel, which screen members (41, 42) are provided with openings (43) which can be aligned or at least partly misaligned with each other depending on the mutual rotational positions of the first screen member (41) and the second screen member (42).
3. A dual fuel burner assembly according to claim 1, **characterized in that** the damper (40) in the central flow channel (34) comprises a first screen member (41) provided with openings (43) and a second screen member (42) provided with openings (43), arranged consecutively into the central flow channel (34), and that the screen members (41, 42) are arranged movable in respect to each other such that their mutual axial distance is arranged adjustable.
4. A dual fuel burner assembly according to claim 1, **characterized in that** the damper (40) in the central flow channel is a multi-plate butterfly damper (40').
5. A dual fuel burner assembly according to claim 1, **characterized in that** the damper (40) in the central flow channel is a vane damper provided with multiple radial vanes (40").
6. A dual fuel burner assembly according to claim 1, **characterized in that** the first fuel inlet (19) comprises a feed pipe (22) arranged coaxially with annular flow channel (32) of the swirl section which feed pipe (22) extends longitudinally through the duct part (12), into which feed pipe the first fuel inlet (19) is arranged.
7. A dual fuel burner assembly according to claim 6, **characterized in that** that first fuel inlet (19) comprises a central feed pipe (22) arranged rotatably in respect to its longitudinal axis (14) and the first screen member (41) is fixed to a body of the swirl section (30) and the second screen member (42) is fixed to the feed pipe (22) such the second screen member (42) is rotatably by the central feed pipe in respect to the first screen member (41).
8. A dual fuel burner assembly according to according to claim 1, **characterized in that** the burner comprises a mixing part (18) arranged between the inlet (15) and the swirl section (30), arranged for mixing a second fuel and combustion air prior to introduction into the swirl section (30).
9. A dual fuel burner assembly according to according to claim 1, **characterized in that** the burner assembly (10) is dimensioned so that a swirl number (S), which is defined by the function

$$S = \frac{2}{3} \tan \alpha \frac{1 - R^3}{1 - R^2 + \left[m^2 \left(\frac{1}{R^2} - 1 \right)^2 \right] R^2}$$

where

α = vane angle at the trailing end in respect to the longitudinal axis (°)

$$m = m_o / m_s$$

m_c = mass flow rate through the central flow channel
 m_s = mass flow rate through the annular flow channel

$$R = R_b / R_B$$

R_B = Burner duct part radius
 R_b = Central flow channel radius

is between 0,4 and 0,55, when the vane angle is between 30° - 42° and the ratio R is 0,5 - 0,7.

10. Method of operating a dual fuel burner assembly (10) according to claim 1 by combusting a first fuel and a second fuel alternatively, **characterized by** combusting the second fuel by maintaining the damper (40) in the central flow channel in a first open position, introducing the second fuel into the combustion air upstream the swirl section (40) of the duct part while refrain from the introduction of the first fuel, and leading first portion of the fuel-air mixture through the central flow channel (34) and a second portion of the fuel-air mixture through the annular flow channel (32) and thus subjecting the second portion into tangential swirl prior to combustion of the second fuel, and by combusting the first fuel by maintaining the damper (40) in the central flow channel in a second open position or by closing the damper in the central flow channel while refrain from the introduction of the second fuel, and leading the combustion air through the annular flow channel and subjecting the combustion air into tangential swirl and introducing the first fuel coaxially with the annular flow channel (32).

11. Method of operating a dual fuel burner assembly according to claim 11, **characterized by** during the combustion of the second fuel adjusting the damper so that a swirl number (S), which is defined by the function

$$S = \frac{2}{3} \tan \alpha \frac{1 - R^3}{1 - R^2 + \left[m^2 \left(\frac{1}{R^2} - 1 \right)^2 \right] R^2}$$

where

α = vane angle at the trailing end in respect to the longitudinal axis (°)

$$m = m_c / m_s$$

m_c = mass flow rate through the central flow channel
 m_s = mass flow rate through the annular flow channel

$$R = R_b / R_B$$

R_B = Burner duct part radius
 R_b = Central flow channel radius

is between 0,4 and 0,55, when the vane angle is between 30° - 42° and the ratio R is 0,5 - 0,7.

Patentansprüche

1. Dualbrennstoffbrenneranordnung (10), umfassend einen Kanalteil (12) zum Einführen von Verbrennungsluft, einen Einlass (15) des Kanalteils (12) an seinem ersten Ende, einen Auslass (16) des Kanalteils an seinem zweiten Ende und Mittel zum Einführen von einem ersten und einem zweiten Brennstoff in den Brenner (15, 17, 19), wobei der Kanalteil (12) mit einem Drallabschnitt (30) zwischen dem Einlass (15) und dem Auslass (16) versehen ist und der Drallabschnitt (30) des Kanalteils (12) einen ringförmigen äußeren Strömungskanal (32) umfasst, der mit Leitblechen (38) versehen ist, die derart angeordnet sind, dass sie ein Gas, das durch den ringförmigen Strömungskanal strömt, im Betrieb mit einer tangentialen Komponente versehen, und die Mittel zum Einführen von Brennstoff in den Brenner

(15, 17, 19) einen ersten Brennstoffeinlass (19) umfassen, der zu dem ringförmigen Strömungskanal (32) des Drallabschnitts in der Nähe des Auslasses (16) des Brenners coaxial angeordnet ist, **dadurch gekennzeichnet, dass** der Drallabschnitt des Kanalteils zum Einführen von Verbrennungsluft einen zentralen Strömungskanal (34) umfasst, der von dem äußeren Strömungskanal (32) radial umschlossen ist, und der zentrale Strömungskanal (34) des Kanalteils (12) mit einer Klappe (40) versehen ist, die konfiguriert ist, den Strömungswiderstand des zentralen Strömungskanals (34) anzupassen.

2. Dualbrennstoffbrenneranordnung nach Anspruch 1, **dadurch gekennzeichnet, dass** die Klappe (40) in dem zentralen Strömungskanal (34) ein erstes Siebelement (41) und ein zweites Siebelement (42) umfasst, die in dem zentralen Strömungskanal nacheinander angeordnet sind, wobei die Siebelemente (41, 42) mit Öffnungen (43) versehen sind, die abhängig von den gegenseitigen Drehpositionen des ersten Siebelements (41) und des zweiten Siebelements (42) zueinander ausgerichtet oder mindestens teilweise unausgerichtet sein können.
3. Dualbrennstoffbrenneranordnung nach Anspruch 1, **dadurch gekennzeichnet, dass** der Dämpfer (40) in dem zentralen Strömungskanal (34) ein mit Öffnungen (43) versehenes erstes Siebelement (41) und ein mit Öffnungen (43) versehenes zweites Siebelement (42) umfasst, die in dem zentralen Strömungskanal (34) nacheinander angeordnet sind, und dass die Siebelemente (41, 42) in Bezug zueinander beweglich angeordnet sind, sodass ihr gegenseitiger axialer Abstand anpassbar angeordnet ist.
4. Dualbrennstoffbrenneranordnung nach Anspruch 1, **dadurch gekennzeichnet, dass** die Klappe (40) in dem zentralen Strömungskanal eine Mehrplattendrosselklappe (40') ist.
5. Dualbrennstoffbrenneranordnung nach Anspruch 1, **dadurch gekennzeichnet, dass** die Klappe (40) in dem zentralen Strömungskanal eine Leitblechklappe ist, die mit mehreren radialen Leitblechen (40'') versehen ist.
6. Dualbrennstoffbrenneranordnung nach Anspruch 1, **dadurch gekennzeichnet, dass** der erste Brennstoffeinlass (19) ein zu dem ringförmigen Strömungskanal (32) des Drallabschnitts coaxial angeordnetes Zuführungsrohr (22) umfasst, wobei sich das Zuführungsrohr (22) in Längsrichtung durch den Kanalteil (12) erstreckt und in das Zuführungsrohr hinein der erste Brennstoffeinlass (19) angeordnet ist.
7. Dualbrennstoffbrenneranordnung nach Anspruch 6, **dadurch gekennzeichnet, dass** der erste Brennstoffeinlass (19) ein zentrales Zuführungsrohr (22) umfasst, das in Bezug auf seine Längsachse (14) drehbar angeordnet ist, und dass das erste Siebelement (41) an einem Körper des Drallabschnitts (30) befestigt ist und das zweite Siebelement (42) an dem Zuführungsrohr (22) befestigt ist, sodass das zweite Siebelement (42) mittels des zentralen Zuführungsrohrs in Bezug auf das erste Siebelement (41) drehbar ist.
8. Dualbrennstoffbrenneranordnung nach Anspruch 1, **dadurch gekennzeichnet, dass** der Brenner einen zwischen dem Einlass (15) und dem Drallabschnitt (30) angeordneten Mischteil (18) umfasst, der zum Mischen von einem zweiten Brennstoff und Verbrennungsluft vor der Einführung in den Drallabschnitt (30) ausgeführt ist.
9. Dualbrennstoffbrenneranordnung nach Anspruch 1, **dadurch gekennzeichnet, dass** die Brenneranordnung (10) derart dimensioniert ist, dass eine Drallzahl (S), die definiert ist durch die Funktion

$$S = \frac{2}{3} \tan \alpha \frac{1 - R^3}{1 - R^2 + \left[m^2 \left(\frac{1}{R^2} - 1 \right)^2 \right] R^2}$$

wobei

α = Leitblechwinkel am hinteren Ende in Bezug auf die Längsachse (°)

$$m = m_c / m_s$$

m_c = Massendurchsatz durch den zentralen Strömungskanal

m_s = Massendurchsatz durch den ringförmigen Strömungskanal

$$R = R_b/R_B$$

R_B = Brennerkanalteiltradius

R_b = zentraler Strömungskanalradius,

zwischen 0,4 und 0,55 liegt, wenn der Leitblechwinkel zwischen 30° und 42° liegt und das Verhältnis R 0,5 bis 0,7 beträgt.

10. Verfahren zum Betreiben einer Dualbrennstoffbrenneranordnung (10) nach Anspruch 1 durch abwechselndes Verbrennen eines ersten Brennstoffs und eines zweiten Brennstoffs, **gekennzeichnet durch** Verbrennen des zweiten Brennstoffs durch Aufrechterhalten der Klappe (40) in einer ersten offenen Position in dem zentralen Strömungskanal, Einleiten des zweiten Brennstoffs in die Verbrennungsluft zuströmseitig des Drallabschnitts (30) des Kanalteils, während von der Einleitung des ersten Brennstoffs abgesehen wird, und Leiten des ersten Teils des Brennstoff-Luft-Gemischs durch den zentralen Strömungskanal (34) und eines zweiten Teils des Brennstoff-Luft-Gemischs durch den ringförmigen Strömungskanal (32) und daher Unterwerfen des zweiten Teils gegenüber einer tangentialen Verwirbelung vor der Verbrennung des zweiten Brennstoffs, und durch Verbrennen des ersten Brennstoffs, indem die Klappe (40) in dem zentralen Strömungskanal in einer zweiten offenen Position aufrechterhalten wird oder indem die Klappe in dem zentralen Strömungskanal geschlossen wird, während von der Einleitung des zweiten Brennstoffs abgesehen wird, und Leiten der Verbrennungsluft durch den ringförmigen Strömungskanal und Unterwerfen der Verbrennungsluft gegenüber einer tangentialen Verwirbelung und Einleiten des ersten Brennstoffs coaxial mit dem ringförmigen Strömungskanal (32).

11. Verfahren zum Betreiben einer Dualbrennstoffbrenneranordnung nach Anspruch 10, **dadurch gekennzeichnet, dass** während der Verbrennung des zweiten Brennstoffs die Klappe derart angepasst wird, dass eine Drallzahl (S), die definiert ist durch die Funktion

$$S = \frac{2}{3} \tan \alpha \frac{1 - R^3}{1 - R^2 + \left[m^2 \left(\frac{1}{R^2} - 1 \right)^2 \right] R^2}$$

wobei

α = Leitblechwinkel am hinteren Ende in Bezug auf die Längsachse (°)

$$m = m_c/m_s$$

m_c = Massendurchsatz durch den zentralen Strömungskanal

m_s = Massendurchsatz durch den ringförmigen Strömungskanal

$$R = R_b/R_B$$

R_B = Brennerkanalteiltradius

R_b = zentraler Strömungskanalradius,

zwischen 0,4 und 0,55 liegt, wenn der Leitblechwinkel zwischen 30° und 42° liegt und das Verhältnis R 0,5 bis 0,7 beträgt.

Revendications

1. Ensemble de brûleur à deux combustibles (10) comprenant une partie de conduit (12) pour l'introduction d'air de combustion, une entrée (15) de la partie de conduit (12) à sa première extrémité, une sortie (16) de la partie de conduit à sa deuxième extrémité et des moyens pour l'introduction d'un premier et d'un deuxième combustible dans le brûleur (15, 17, 19), dans lequel la partie de conduit (12) est dotée d'une section de tourbillonnement (30) entre

l'entrée (15) et la sortie (16), et la section de tourbillonnement (30) de la partie de conduit (12) comprend un canal d'écoulement extérieur annulaire (32) doté d'ailettes (38) conçues pour fournir une composante tangentielle à un gaz s'écoulant à travers le canal d'écoulement annulaire pendant l'utilisation, et les moyens pour l'introduction de combustible dans le brûleur (15, 17, 19) comprennent une première entrée de combustible (19) disposée coaxialement avec le canal d'écoulement annulaire (32) de la section de tourbillonnement à proximité de la sortie (16) du brûleur, **caractérisé en ce que** la section de tourbillonnement de la partie de conduit pour l'introduction d'air de combustion comprend un canal d'écoulement central (34) entouré radialement par le canal d'écoulement extérieur (32), et le canal d'écoulement central (34) de la partie de conduit (12) est doté d'un registre (40) configuré pour régler une résistance à l'écoulement du canal d'écoulement central (34).

2. Ensemble de brûleur à deux combustibles selon la revendication 1, **caractérisé en ce que** le registre (40) dans le canal d'écoulement central (34) comprend un premier élément de blindage (41) et un deuxième élément de blindage (42) disposés successivement dans le canal d'écoulement central, lesdits éléments de blindage (41, 42) sont dotés d'ouvertures (43) aptes à être alignées ou au moins partiellement désalignées les unes par rapport aux autres en fonction des positions de rotation mutuelles du premier élément de blindage (41) et du deuxième élément de blindage (42).
3. Ensemble de brûleur à deux combustibles selon la revendication 1, **caractérisé en ce que** le registre (40) dans le canal d'écoulement central (34) comprend un premier élément de blindage (41) doté d'ouvertures (43) et un deuxième élément de blindage (42) doté d'ouvertures (43), disposés successivement dans le canal d'écoulement central (34), et **en ce que** les éléments de blindage (41, 42) sont disposés de façon déplaçable l'un par rapport à l'autre, de sorte que leur distance axiale mutuelle est réglable.
4. Ensemble de brûleur à deux combustibles selon la revendication 1, **caractérisé en ce que** le registre (40) dans le canal d'écoulement central est un registre papillon à plateaux multiples (40').
5. Ensemble de brûleur à deux combustibles selon la revendication 1, **caractérisé en ce que** le registre (40) dans le canal d'écoulement central est un registre à ailettes doté d'une multitude d'ailettes radiales (40'').
6. Ensemble de brûleur à deux combustibles selon la revendication 1, **caractérisé en ce que** la première entrée de combustible (19) comprend un tuyau d'alimentation (22) disposé coaxialement avec le canal d'écoulement annulaire (32) de la section de tourbillonnement, ledit tuyau d'alimentation (22) s'étendant longitudinalement à travers la partie de conduit (12), la première entrée de combustible (19) étant disposée dans ledit tuyau d'alimentation.
7. Ensemble de brûleur à deux combustibles selon la revendication 6, **caractérisé en ce que** la première entrée de combustible (19) comprend un tuyau d'alimentation central (22) disposé de façon rotative par rapport à son axe longitudinal (14) et le premier élément de blindage (41) est fixé à un corps de la section de tourbillonnement (30) et le deuxième élément de blindage (42) est fixé au tuyau d'alimentation (22) de telle façon que le deuxième élément de blindage (42) peut être mis en rotation par le tuyau d'alimentation central par rapport au premier élément de blindage (41).
8. Ensemble de brûleur à deux combustibles selon la revendication 1, **caractérisé en ce que** le brûleur comprend une partie de mélange (18) disposée entre l'entrée (15) et la section de tourbillonnement (30), conçue pour mélanger un deuxième combustible et de l'air de combustion avant l'introduction dans la section de tourbillonnement (30).
9. Ensemble de brûleur à deux combustibles selon la revendication 1, **caractérisé en ce que** l'ensemble de brûleur (10) est dimensionné de telle façon qu'un indice de tourbillon (S), lequel est défini par la fonction suivante

$$S = \frac{2}{3} \tan \alpha \frac{1 - R^3}{1 - R^2 + \left[m^2 \left(\frac{1}{R^2} - 1 \right)^2 \right] R^2}$$

où

α = angle d'ailette à l'extrémité arrière par rapport à l'axe longitudinal (°)

$$m = m_c / m_s$$

m_c = débit massique à travers le canal d'écoulement central

m_s = débit massique à travers le canal d'écoulement annulaire

$$R = R_b / R_B$$

R_B = rayon de partie de conduit du brûleur

R_b = rayon de canal d'écoulement central

est compris entre 0,4 et 0,55, lorsque l'angle d'aillette est compris entre 30° et 42° et que le rapport R est compris entre 0,5 et 0,7.

10. Procédé de fonctionnement d'un ensemble de brûleur à deux combustibles (10) selon la revendication 1 par combustion d'un premier combustible et d'un deuxième combustible alternativement, **caractérisé par** la combustion du deuxième combustible par maintien du registre (40) dans le canal d'écoulement central dans une première position ouverte, introduction du deuxième combustible dans l'air de combustion en amont de la section de tourbillonnement (40) de la partie de conduit tout en empêchant l'introduction du premier combustible, et guidage d'une première portion du mélange combustible-air à travers le canal d'écoulement central (34) et d'une deuxième portion du mélange combustible-air à travers le canal d'écoulement annulaire (32), soumettant ainsi la deuxième portion à un tourbillonnement tangentiel avant la combustion du deuxième combustible, et par la combustion du premier combustible par maintien du registre (30) dans le canal d'écoulement central dans une deuxième position ouverte ou par fermeture du registre dans le canal d'écoulement central tout en empêchant l'introduction du deuxième combustible, et guidage de l'air de combustion à travers le canal d'écoulement annulaire et soumission de l'air de combustion à un tourbillonnement tangentiel et introduction du premier combustible coaxialement avec le canal d'écoulement annulaire (32).

11. Procédé de fonctionnement d'un ensemble de brûleur à deux combustibles selon la revendication 10, **caractérisé en ce que** pendant la combustion du deuxième combustible, le registre est réglé de telle façon qu'un indice de tourbillon (S), lequel est défini par la fonction suivante

$$S = \frac{2}{3} \tan \alpha \frac{1 - R^3}{1 - R^2 + \left[m^2 \left(\frac{1}{R^2} - 1 \right)^2 \right] R^2}$$

où

α = angle d'aillette à l'extrémité arrière par rapport à l'axe longitudinal (°)

$$m = m_c / m_s$$

m_c = débit massique à travers le canal d'écoulement central

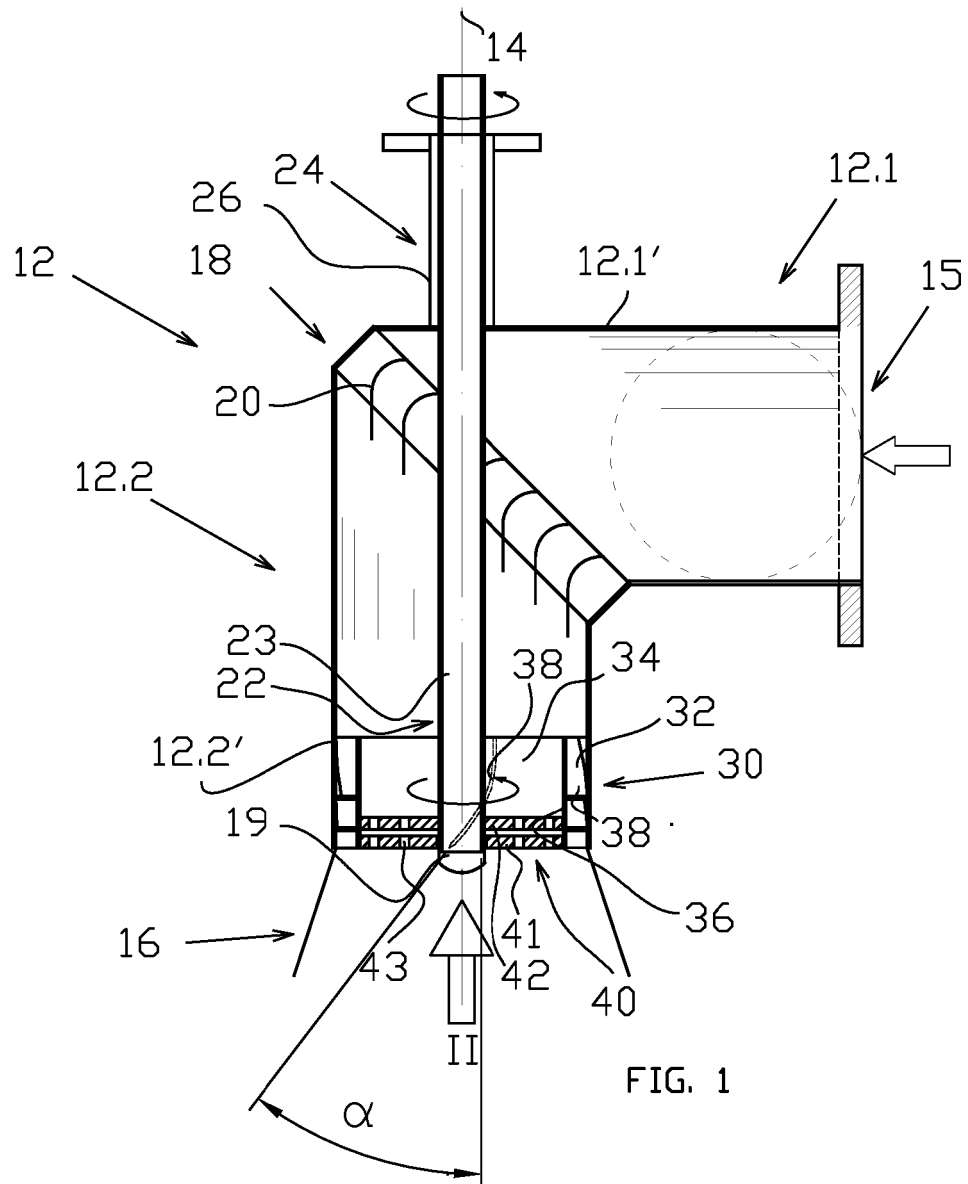
m_s = débit massique à travers le canal d'écoulement annulaire

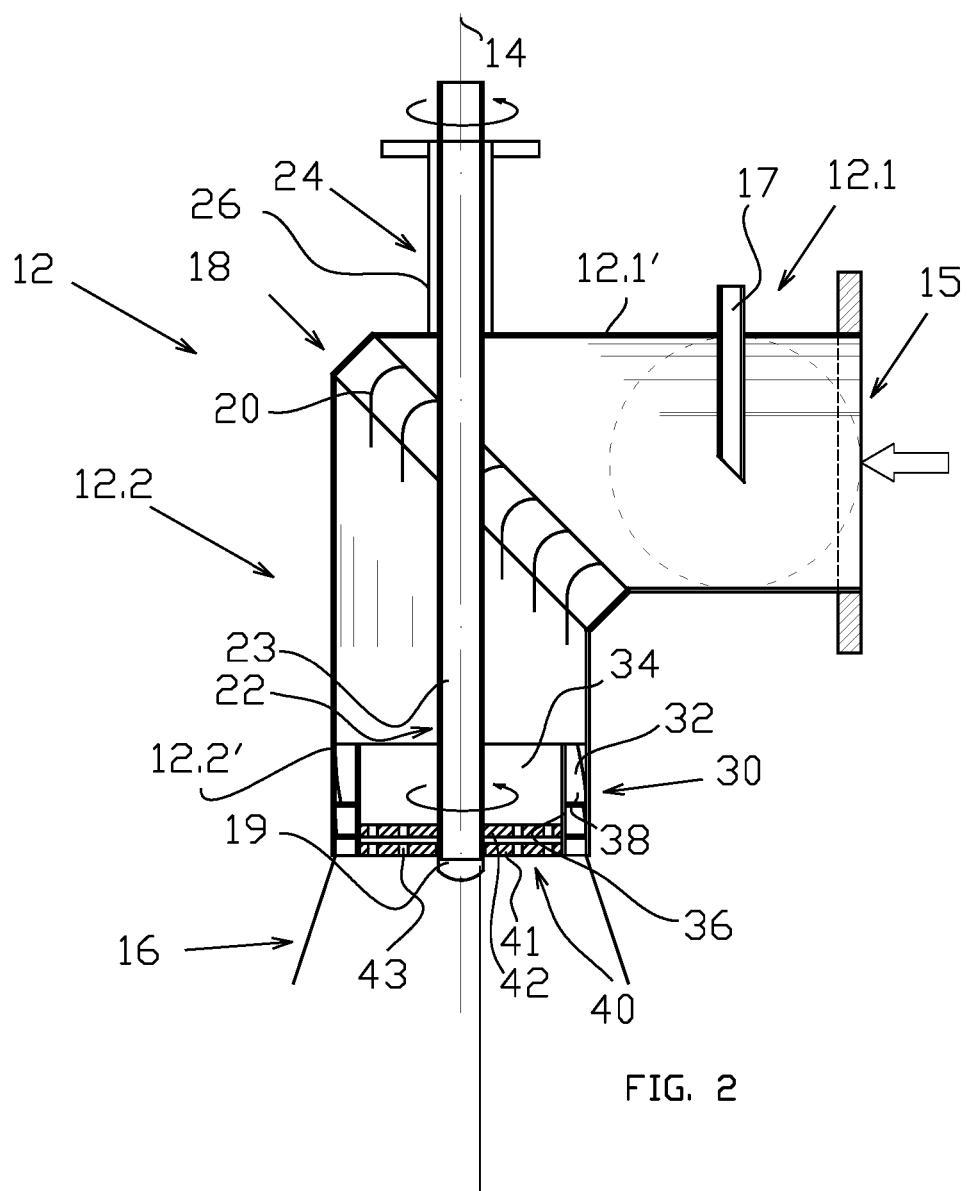
$$R = R_b / R_B$$

R_B = rayon de partie de conduit du brûleur

R_b = rayon de canal d'écoulement central

est compris entre 0,4 et 0,55, lorsque l'angle d'aillette est compris entre 30° et 42° et que le rapport R est compris entre 0,5 et 0,7.





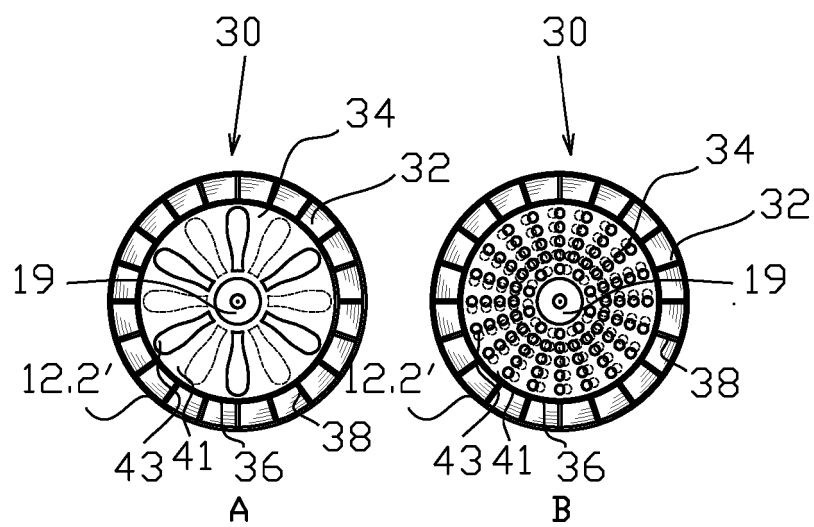
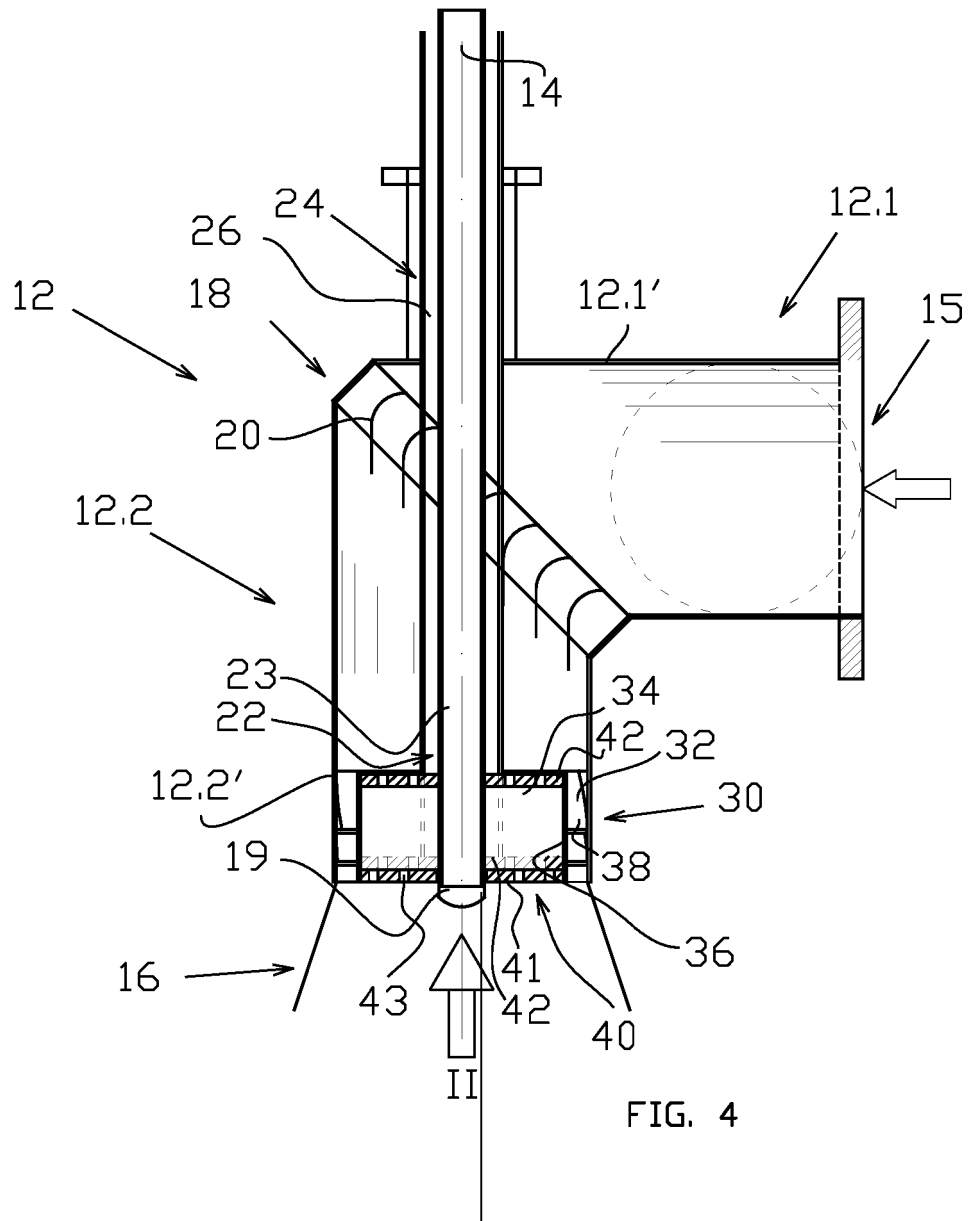


FIG. 3



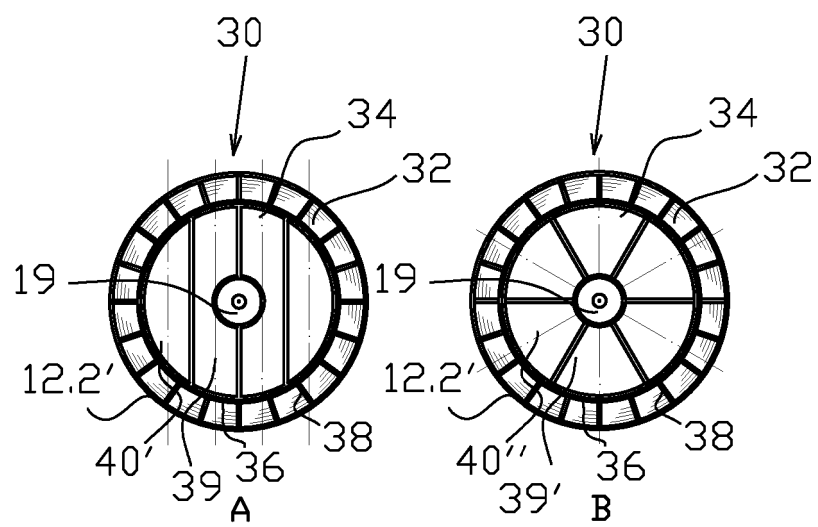


FIG. 5

REFERENCES CITED IN THE DESCRIPTION

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